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Geotechnical Evaluation Report

Platte and Wooten Bridge Replacement

Wooten Road at Platte Avenue

Colorado Springs, Colorado

VIVID Project No.: D19-2-268

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Report prepared for:

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GEOTECHNICAL EVALUATION REPORT
Platte and Wooten Bridge Replacement
North of the intersection of Platte Ave. and Wooten Rd.
Colorado Springs, Colorado
VIVID Project No. D19-2-268

Prepared by:

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Table of Contents

1.0 INTRODUCTION

1.1 General

This report presents the results of a geotechnical investigation performed for the proposed Platte Avenue and Wooten Road bridge replacement project, located on the north side of the intersection of Platte Avenue and Wooten Road in Colorado Springs, Colorado. An attached Vicinity Map (Figure 1) shows the general location of the project. Our investigation was performed for AECOM and was authorized by Ms. Reynee Nuetzel, P.E.

This report includes our recommendations relating to the geotechnical aspects of project design and construction. The conclusions and recommendations stated in this report are based upon the subsurface conditions found at the locations of our exploratory borings at the time our exploration was performed. They also are subject to the provisions stated in the report section titled **Additional Services & Limitations**. Our findings, conclusions, and recommendations should not be extrapolated to other areas or used for other projects without our prior review. Furthermore, they should not be used if the site has been altered, or if a prolonged period has elapsed since the date of the report, without VIVID's prior review to determine if they remain valid.

1.2 Project Description

We understand the project may include the removal and replacement of the existing culverts and headwalls under Wooten Road on the north side of Platte Avenue, in Colorado Springs. During the time of our investigation, the 3 existing corrugated metal pipes were being evaluated to determine whether replacement was necessary. We understand that if the removal and replacement of the pipes is determined necessary, the replacement structures may include a box culvert, precast arch structure or new larger culvert pipes with head walls. The existing lane configuration will be maintained with additional width to accommodate a pedestrian crosswalk on the west side of the structure and new curb and gutter. Areas of new asphalt pavement is planned at the bridge approach areas and bridge surface. Additional construction activities are anticipated to include associated minor site grading.

Anticipated loading conditions and movement tolerances for the bridge structure were not provided at the time this report was published. For estimating purposes, we have assumed that, in general, planned cuts and fills to achieve finish site grades within the bridge area will be on the order of 3 feet or less. We anticipate the final grade of the proposed replacement will be similar to the existing grade. VIVID should be notified in order to review and revise our recommendations if the construction varies from that presented above.

1.3 Purpose and Scope

The purpose of our investigation was to explore and evaluate subsurface conditions at various locations near the proposed project improvements and, based upon the conditions found, to develop recommendations relating to the geotechnical aspects of project design and construction. Our conclusions and recommendations in this report are based upon analysis of the data from our field exploration, laboratory tests, and our experience with similar soil and geologic conditions in the area.

VIVID's scope of services included:

- A visual reconnaissance to observe surface and geologic conditions at the project site and locating the exploratory borings;
- Notification of the Utility Notification Center of Colorado (UNCC)/Colorado 811 to identify underground utility lines at the boring locations prior to our drilling;
- The drilling of two exploratory borings near the proposed bridge replacement location which were selected based upon the proposed construction plans, access, and the locations of existing utilities;
- Laboratory testing of selected samples obtained during the field exploration to evaluate relevant physical and engineering properties of the soil;
- Evaluation and engineering analysis of the field and laboratory data collected to develop our geotechnical conclusions and recommendations; and
- Preparation of this report, which includes a description of the proposed project, a description of the surface and subsurface site conditions found during our investigation, our conclusions and recommendations as to foundation design, pavement section thickness design, other related geotechnical issues, and appendices which summarize our field and laboratory investigations.

2.0 FIELD EXPLORATION AND LABORATORY TESTING

2.1 Field Exploration

A field exploration performed on December 5, 2019 included drilling two exploratory borings at the approximate locations indicated on the attached Boring Location Plan shown on Figure 2. A summary of the explorations is presented below:

Table 1
Summary of Subsurface Exploration

Boring Designation	Approximate Boring Depth [feet, below ground surface]	Approximate Depth to Groundwater [feet, below ground surface]
B-1	25	22[1]
B-2	25.5	22[1]

1) Indicates groundwater level encountered in boring at time of drilling.

The borings were advanced with a truck-mounted CME-55 drill rig equipped with 3-inch outside diameter, continuous-flight auger. Samples were taken with a 2.5-inch O.D./2.0-inch I.D. California-type sampler, standard penetration (SPT) sampler, and by bulk methods. Penetration tests were obtained at the various sample depths as well.

Appendix A to this report includes logs describing the subsurface conditions. The lines defining boundaries between soil types on the logs are based upon drill behavior and interpolation between samples and are therefore approximate. Transition between soil types may be abrupt or may be gradual.

2.2 Geotechnical Laboratory Testing

Laboratory tests were performed on selected soil samples to estimate their relative engineering properties. Tests were performed in general accordance with the following methods of ASTM or other recognized standards-setting bodies, and local practice:

- Description and Identification of Soils (Visual-Manual Procedure)
- Classification of Soils for Engineering Purposes
- Moisture Content and Unit Weight
- Sieve Analysis of Fine and Coarse Aggregates
- Liquid Limit, Plastic Limit, and Plasticity Index
- Swell/Settlement
- Unconfined Compressive Strength
- R-value

Results of the geotechnical laboratory tests are included in Appendix B of this report. Selected test results are also shown on the boring logs in Appendix A.

2.3 Analytical Laboratory Testing

Analytical testing for soil corrosivity was performed on a selected sample and included the following tests:

- pH
- Resistivity
- Redox Potential
- Water-soluble Sulfates
- Water-soluble Chlorides
- Sulfides

Results of the analytical laboratory tests are included in Appendix C of this report.

3.0 SITE CONDITIONS

3.1 Surface

At the time of our investigation, the existing bridge structure consisted of 3 corrugated metal pipes crossing under Wooten Road with head walls and wing walls on either side. The existing corrugated pipes reportedly contain holes, tears and some warping based on photos provided to us that were taken during the 2018 Minor Bridge inspection performed by others. The ephemeral, Sand Creek West Fork stream channel that runs under Wooten Road was overgrown with grasses and brush. At the location of the bridge, Wooten Road consisted of 5 traffic lanes. A concrete cross-pan spanned northeast to southwest across Wooten Road, just north of the bridge. A gas station was located at the northeast corner of the intersection. Edison Avenue intersects with Wooten Road from the west, just north of the bridge. Office buildings are located on the northwest corner of the intersection, north of Edison Avenue. Platte Avenue was located immediately south of the site.

3.2 Geology

Prior to drilling, the site geology was evaluated by reviewing geologic maps including the Colorado Geological Survey geologic map of the Elsmere 7.5 Minute Quadrangle, El Paso County, Colorado (Madole and Thorson, 2003). Mapping indicates the surficial soils in the general area of the project site comprise predominantly of alluvium deposits of sand, gravel and clay underlain by claystone and shale bedrock of the Pierre Shale Formation. The mapping is generally consistent with the materials encountered in our explorations. However, we did not encounter bedrock in our borings.

3.3 Seismicity

Based upon the geologic setting, subsurface soil conditions, and low seismic activity in this region, liquefaction is not expected to be a hazard at the site. Based on correlation of blow count data (N-values) from the borings advanced during this evaluation, the subsurface bedrock profiles correspond with 2009 AASHTO Site Class D. The intermediate design acceleration values are presented below.

Table 2
Design Acceleration for Short Periods

S_S	F_a
0.176	1.6

S_S = The mapped spectral accelerations for short periods (U.S. Geological Survey Web Page, 2019)

F_a = Site coefficient (U.S. Geological Survey Web Page, 2019)

Table 3
Design Acceleration for 1-Second Period

S_1	F_V
0.06	2.4

S_1 = The mapped spectral accelerations for 1-second period (U.S. Geological Survey Web Page, 2019)

F_v = Site coefficient (U.S. Geological Survey Web Page, 2019)

3.4 Subsurface

VIVID explored the subsurface conditions by drilling, logging, and sampling two exploratory borings within or as near as possible to the general area to be occupied by the proposed bridge replacement and new pavement areas, as shown approximately on Figure 2. These borings were drilled to depths of approximately 25 and 25.5 feet below the existing ground surface. The general profile encountered in our borings consisted of:

<u>Asphalt and Granular Base Materials</u>

Approximately 5 to 6 inches of existing asphalt was encountered at the ground surface in the borings. Approximately 6 to 18 inches of granular base materials were encountered underlying the asphalt. The base materials were generally comprised of silty sand with gravel, and were reddish-brown in color, moist, and medium dense.

<u>Sand and Clay</u>

Soils comprised predominantly of fat clay and clayey to very clayey sand were encountered below the pavement section and extended to depths up to approximately 25.5 feet below the ground surface. A thin layer of silty sand was encountered below the pavement section in B-2. The clay and clayey sand materials were generally light brown to dark brown, olive or rust-colored, moist to wet, and field penetration testing (blow counts) indicated the relative density of the clay soils were generally soft to stiff and the clayey sand was loose to medium dense. We performed a swell/consolidation test on the sample from B-1 at 7 feet below existing grade in our laboratory which exhibited a measured swell of 0.1 percent when wetted under 1,000 psf. It should be noted that the moisture content of the clay soils that are located at anticipated foundation elevations was above the soil's plastic limit. This indicates soft and unstable soil conditions can be expected at foundation elevations.

3.4.1 Groundwater

Groundwater was encountered in both borings at a depth of approximately 22 feet below the existing ground surface at the time of drilling. Borings were backfilled immediately after drilling due to being an active roadway. Based on the high soil moisture content, the static groundwater level may be higher than measured during drilling. Due to the location of the proposed structure and roadway alignment adjacent to an active drainage channel, both surface and groundwater will be a consideration for construction of bridge foundation elements. Groundwater levels commonly vary over time and space depending on seasonal precipitation, irrigation practices, land use, and runoff conditions. These conditions and the variations that they create often are not apparent at the time of field investigation. Accordingly, the soil moisture and groundwater data in this report pertain only to the locations and times at which exploration was performed. They can be extrapolated to other locations and times only with caution. It should also be noted that VIVID has not performed a hydrologic study to verify the seasonal high-water level.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 GEOTECHNICAL FEASIBILITY OF PROPOSED CONSTRUCTION

VIVID found no subsurface conditions during this investigation that would preclude construction of the improvements essentially as planned, provided the recommendations in this report are incorporated into the design and construction of the project.

Shallow Foundation System

Geotechnical design parameters for the possible bridge replacement structures are presented in Section 4.3. To create more uniform and stable subgrade conditions and facilitate construction in wet conditions for new foundations, we recommend a 24-inch zone of structural fill to be placed beneath the foundation of the replacement structure and any associated wall shallow foundation elements. The over-excavation and fill placement process is described in more detail below.

The presence of surface water and groundwater creates loose/soft and very moist to wet soil conditions as found in our borings. Therefore, construction dewatering, shoring, and difficult construction conditions should be expected on this site. Recommendations for construction dewatering, subgrade stabilization, and shoring are provided below.

Further detail regarding our geotechnical design and construction recommendations for site preparation, pavements, foundations, and other related construction topics are provided in the following sections.

4.2 CONSTRUCTION CONSIDERATIONS

4.2.1 General

All site preparation and earthwork operations should be performed in accordance with applicable codes, safety regulations and other local, State or Federal guidelines.

4.2.2 Subgrade Preparation

Initial site work should consist of completely removing all existing structures, organic material and other deleterious materials from all areas to be filled and areas to be cut. All material should be removed for offsite disposal in accordance with local laws and regulations or, if appropriate, stockpiled in proposed landscaped areas for future use. Areas to receive fill should be evaluated by the geotechnical engineer prior to the placement of any fill materials.

After performing the required excavations and prior to the placement of compacted fill, processing of the subgrade should be performed. This should include scarifying the subgrade to a depth of at least 8 inches, moisture conditioning, and compacting as recommended in Section 4.2.5 of this report. Where unstable conditions exist and proper moisture conditioning and compaction is not feasible, stabilization of the subgrade as described in Section 4.3 will be required. Due to high soil moisture contents, stabilization is anticipated anywhere excavations extend near or into the clay subgrade. All fill materials should be placed on a horizontal plane and placed in loose lifts not to exceed 8 inches in thickness, unless otherwise accepted by the geotechnical engineer. Additional subgrade preparation and stabilization for specific project elements such as box culvert/wing wall foundations and pavement subgrade are provided in the sections of this report that specifically address these elements.

4.2.3 Excavation Characteristics

Proposed site grading plans were not provided to us prior to compilation of this report. We anticipate cuts and fills for general site grading will be minimal and may be on the order of about 1 to 3 feet or less. Boring logs should be reviewed to evaluate material type and groundwater conditions.

Sand and Clay Materials

We believe that excavation of the sand and clay soils can be readily accomplished using standard-duty excavating equipment.

Dewatering/Shoring

Proposed earthwork and excavation operations will be within or adjacent to the Sand Creek west fork drainage channel. **The existence and elevation of surface water flows and groundwater is highly dependent on time of year and runoff conditions. The groundwater elevation can vary significantly in this area.** Therefore, surface and possibly groundwater infiltration will occur below creek elevations during construction operations, requiring construction dewatering. Utilizing appropriate construction dewatering equipment/systems such as well points or sumps, and trenches, will be the responsibility of the contractor. In addition, trenching into unstable, saturated overburden soils will require temporary shoring, where construction of safe slopes is not feasible. OSHA requirements for excavation in unstable materials should be followed.

All excavations must comply with applicable local, State and Federal safety regulations, and particularly with the excavation standards of the Occupational Safety and Health Administration (OSHA). Construction site safety, including excavation safety, is the sole responsibility of the Contractor as part of its overall responsibility for the means, methods and sequencing of construction operations. VIVID's recommendations for excavation support are intended for the Client's use in planning the project, and in no way relieve the Contractor of its responsibility to construct, support and maintain safe slopes. Under no circumstances should the following recommendations be interpreted to mean that VIVID is assuming responsibility for either construction site safety or the Contractor's activities.

We believe that the unsaturated soils on this site will classify as Type C materials using OSHA criteria. OSHA requires that unsupported cuts in Type C materials be laid back to ratios no steeper than 1½:1 (horizontal to vertical). Where groundwater occurs, flatter slopes will be required. This condition is anticipated where earthwork/excavation extends below creek elevation. Please note that the actual determination of soil type and allowable sloping must be made in the field by an OSHA-qualified "competent person."

Although erosion analysis is beyond the scope of our evaluation, it is generally recommended that embankment slopes be armored and/or well vegetated (with appropriate grass cover) to assist in reducing the influence of water that may flow over the face of the embankment, regardless of embankment material type.

4.2.4 Structural Fill

Specific recommendations in regard to depth and type of structural fill is presented in the following sections of this report for foundations, retaining walls, pavements, embankments, etc.

Foundation and Wing Wall Subgrade

To form a uniform and stable subgrade layer and minimize differential movement of the structure, we recommend foundations be constructed on at least 24-inches of moisture conditioned and densely compacted structural fill. Structural fill for use as foundation subgrade backfill for the replacement structure and associated wall structures is described in Section 4.3.

Wall Drainage Zone

A 12-inch wide zone of No. 57 stone should be placed adjacent to structure walls and wing walls to act as a wall drainage layer to facilitate groundwater movement around structures and limit build-up of hydrostatic pressures. The top of the drainage material behind the walls should not extend any closer than within 18 inches of the proposed ground surface. Use of a filter fabric will be required to prevent the fine site soils from migrating into the No. 57 stone drainage layer against the walls.

Wall Backfill

Fill placed adjacent and within the lateral earth pressure zone of influence to bridge abutments, box culvert walls or wing walls must meet CDOT Class I Structure Backfill specifications. Due to the poor characteristics of the on-site clay soils, on-site soils should not be used as structure backfill.

Fill materials should be compacted according to the recommendations in Section 4.2.5 of this report. We recommend that a qualified representative of VIVID visit the site during excavation and during placement of the fill to verify the soils exposed in the excavations are consistent with those encountered during our subsurface exploration and that proper foundation subgrade preparation and placement is performed.

4.2.5 Fill Placement and Compaction

Fill materials should be placed in horizontal lifts compatible with the type of compaction equipment being used, moisture conditioned, and compacted in accordance with the following criteria:

Table 4
Fill Placement and Compaction Criteria

Fill Location	Material Type	Percent Compaction[1] (ASTM D1557)	Moisture Content
Subgrade Preparation (after clearing, grubbing, excavation, and prior to placement of new fill and/or structural elements)	On-site Soils	92 minimum or stabilization	± 2 % of optimum
Foundation Subgrade (Box Culvert and Wing Wall Structures)	Clean, "Crushed" Aggregate (No. 57 Stone) (See Section 4.4)	N/A[2]	N/A
12-inch Drainage Zone (Behind Box Culvert and Wing Wall Structures)	Clean, "Crushed" Aggregate (No. 57 Stone) (See Sections 4.2.4 and 4.4)	N/A[2]	N/A

Fill Location	Material Type	Percent Compaction[1] (ASTM D1557)	Moisture Content
Retaining Wall Backfill (Box Culverts, Wing Walls)	CDOT Class I Structure Backfill (See Sections 4.2.4 and 4.4)	95 minimum	± 2 % of optimum
Aggregate Base Course	CDOT Class 5 or 6 Aggregate Base Course	95 minimum	± 2 % of optimum
Utility Trench Backfill/ Flatwork Subgrade	On-site Soils/Imported Granular Structural Fill	95 minimum	± 2 % of optimum

1) In non-structural/landscaped areas, the compaction specification may be reduced to 90 percent. The higher compaction criteria should be utilized where two or more "fill locations" coincide.
2) No. 57 stone material should be placed in maximum 8-inch lift with compaction, but no testing required.

Fill should be placed in level lifts not exceeding 8 inches in loose thickness and compacted to the specified percent compaction to produce a firm and stable surface. If field density tests indicate the required percent compaction has not been obtained, the fill material should be reconditioned as necessary and re-compacted to the required percent compaction before placing any additional material.

Fill against any site or foundation walls should be properly placed and compacted as recommended herein. Backfill should be mechanically compacted in layers (6 to 8 inches maximum loose lift thickness). Care should be taken when placing backfill so as not to damage the walls. Compaction of each lift adjacent to and near the walls should be accomplished with hand-operated tampers or other lightweight compactors. Over-compaction may cause excessive lateral earth pressures, which could result in wall movement, and potentially damage the walls. If required, wall designs may need to consider increased lateral pressures during construction/compaction.

4.2.6 Utility Trench Backfill

Backfill material should be essentially free of plant matter, organic soil, debris, trash, other deleterious matter and rock particles larger than 4 inches. However, backfill material in the "pipe zone" (from the trench floor to 1 foot above the top of pipe) should not contain rock particles larger than 1 inch. Strictly observe any requirements specified by the utility agency for bedding and pipe-zone fill. In general, backfill above the pipe zone in utility trenches should be placed in lifts of 6 to 8 inches, and compacted using power equipment designed for trench work. Backfill in the pipe zone should be placed in lifts of 8 inches or less and compacted with hand-held equipment. Compact trench backfill as recommended in Section 4.2.5 of this report.

4.2.7 Construction in Wet or Cold Weather

During construction, grade the site such that surface water can drain readily away from the structure area. Promptly pump out or otherwise remove any water that may accumulate in excavations or on subgrade surfaces and allow these areas to dry before resuming construction. The use of berms, ditches and similar means may be used to prevent stormwater from entering the work area and to convey any water off site efficiently.

If earthwork is performed during the winter months when freezing is a factor, no grading fill, structural fill or other fill should be placed on frosted or frozen ground, nor should frozen material be placed as fill. Frozen ground should be allowed to thaw or be completely removed prior to placement of fill. A good practice is to cover the compacted fill with a "blanket" of loose fill to help prevent the compacted fill from freezing.

If the structures are erected during cold weather, foundations, concrete slabs-on-grade, or other concrete elements should not be constructed on frozen soil. Frozen soil should be completely removed from beneath the concrete elements, or thawed, scarified and recompacted. The amount of time passing between excavation or subgrade preparation and placing concrete should be minimized during freezing conditions to prevent the prepared soils from freezing. The use of blankets, soil cover or heating as required may be utilized to prevent the subgrade from freezing.

4.2.8 Construction Testing and Observation

Testing and construction observation should take place under the direction of VIVID to support that engineer's professional opinion as to whether the earthwork does or does not substantially conform to the recommendations in this report. Furthermore, the opinions and conclusions of a geotechnical report are based upon the interpretation of a limited amount of information obtained from the field exploration. It is therefore not uncommon to find that actual site conditions differ somewhat from those indicated in the report. The geotechnical engineer should remain involved throughout the project to evaluate such differing conditions as they appear, and to modify or add to the geotechnical recommendations as necessary.

4.2.9 Drainage

Positive drainage away from the proposed improvements (pavements, walls, flatwork, etc) is essential to the performance of foundations and flatwork and should be provided during the life of the structure. Drainage should be created such that water is diverted off the site and away from structures and other improvements.

4.2.10 Permanent Cut and Fill Slopes

If required, permanent cut and fill slopes exposing the materials encountered in our borings are anticipated to be stable at slope ratios as steep as 3:1 (horizontal to vertical) under dry conditions. We believe that slope ratios of 4:1 or flatter are more reliable if subjected to wetting, and present less of a maintenance problem. New slopes should be revegetated as soon as possible after completion to reduce erosion problems. Slopes steeper than that recommended above are possible with proper earth retention and erosion control designs.

4.3 SHALLOW FOUNDATION SYSTEMS

We understand that the existing corrugated pipes may be removed and replaced. The possible replacement structures may include a box culvert, a precast arch structure, or larger additional pipes with head walls. The foundation type of the replacement structures may include spread footings or a shallow reinforced mat foundation system. No plans of the possible replacement structures were provided to our office during this investigation.

The bearing conditions encountered in the borings around the anticipated replacement structure were generally very moist to wet and soft to stiff fat clay with some clayey sand materials. Due to the nature of this site as a drainage and the proposed construction, the replacement structure foundations may be situated near or within groundwater or surface flows. It is this zone of material that will control design and performance of the replacement structure.

To help create a more uniform and stable platform on which to construct the replacement structure and any associated wing wall foundation elements, facilitate dewatering as necessary, and reduce the potential for settlement of the proposed structures, we recommend the box culvert and any associated wall structures be supported on shallow foundations bearing on a minimum 24-inch thick zone of structural fill. In order to provide subgrade improvement, facilitate drainage/dewatering during construction (as necessary), and create a reasonable construction platform, this 24 inches of structural fill should comprise of No. 57 aggregate (see Table 703-1, Section 703, CDOT Standard Specifications for Road and Bridge Construction, 2019). A high strength fabric must be placed between the No. 57 aggregate and surrounding soil. This fabric must have high durability, tensile strength, separation, and filtration characteristics. We recommend utilizing Mirafi HP 370 fabric or equivalent.

Additional subgrade stabilization may also be necessary. **Stabilization techniques can vary but may include use of a heavy-duty geogrid such as Tensar TX-7 with aggregate or rock (1 to 1.5-inch max aggregate size) or pushing rock (typically angular 3 to 12-inch rock) into the subgrade to minimize the instability.**

We also highly recommend lightweight, tracked/low ground pressure equipment be utilized to perform earthwork operations for foundation preparation and to install fill and structural elements. This will help limit damage to the stabilized subgrade and reduce the required amount of stabilization.

Additional recommendations for a shallow mat or footing foundation are presented below.

- Foundations bearing upon a zone of structural fill as described above may be designed for a maximum allowable bearing capacity of 2,000 pounds per square foot (psf).
- We estimated total settlement for shallow foundations placed on soils as discussed above would be about 1 inch or less with potential differential settlement of the order of ½ to ¾ of an inch.
- Shallow foundation elements should have at least 30 inches of cover above the bottom of the foundation for frost protection, or that required by the local building code.
- Loose soil present within the foundation areas should be removed prior to placement of structural fill or concrete.

4.4 RETAINING WALLS

Walls that retain earth on one side (abutment walls, box culvert walls, wing walls, etc.) will be subjected to lateral earth pressures. The design and construction criteria presented below should be observed for earth retention systems on this site with flat back slopes.

Soil Parameters

Walls shall be backfilled with CDOT Class I Structure Backfill for the full width that influences lateral earth pressure. For design purposes, the following average soil parameters can be utilized:

- **CDOT Class I Structure Backfill:** Angle of Internal Friction (phi-angle) = 30 degrees; Unit Weight (unsaturated) = 125 pounds per cubic foot (pcf)

Table 5
Lateral "Equivalent Fluid" Earth Pressure Parameter Summary

Parameter	CDOT Class I Structure Backfill (Above Groundwater)	CDOT Class I Structure Backfill (Below Groundwater)[4]
At-Rest[1]	63 pcf	94 pcf
Active[2]	42 pcf	83 pcf
Passive[3]	375 pcf	188 pcf
Unfactored Coefficient of Sliding Friction[3]	0.58	0.58

Notes: 1. Retaining walls that are laterally supported (structurally restrained from rotation) can be expected to undergo only a slight amount of deflection. These walls should be designed for an "at-rest" lateral earth pressure.

2. Retaining structures which can deflect sufficiently to mobilize the full "active" earth pressure condition should be designed for an "active" lateral earth pressure. For the medium dense sand soils encountered on this site, a wall deflection of at least 0.002H (where is H is the wall height) is required to mobilize active earth pressures.

3. Lateral loads may be resisted using these unfactored coefficients of sliding friction and unfactored passive earth pressures presented above. Because significant movement is required to fully mobilize passive earth pressure, we recommend a minimum factor of safety of 2 be applied for design purposes.

4. It should be noted that the hydrostatic water pressure (62.4 pcf) was already included in the pressure values for below groundwater condition.

To prevent hydrostatic loading on the abutment walls, it is recommended that a layer of free-draining aggregate be placed behind the wall that is hydraulically connected to weep holes or a perforated drain line that is connected to weep holes or drains to a gravity outlet. The free-draining aggregate material should extend vertically above the perforated drain line/weep holes to 18 inches below the ground surface. The drainage aggregate section behind the wall should have a minimum width of 12 inches and should be encapsulated in a suitable filter fabric to minimize intrusion of fines. A less-permeable clay cap should be placed above the free draining granular material to help mitigate infiltration of surface water.

4.5 METAL CORROSIVITY AND CONCRETE SULFATE DEGRADATION

Laboratory chloride concentration, sulfate concentration, sulfide concentration, pH, oxidation reduction potential, and electrical resistivity tests were performed on samples of onsite materials obtained during our field investigation. The results of the tests are included in Appendix C to this report and are summarized below in Table 6.

Table 6
Summary of Laboratory Soil Corrosivity Testing

Boring No.	Sample Depth (ft)	Lithology	Water Soluble Chloride (%)	pH	Redox Potential (mV)	Resistivity (ohm-cm)	Water Soluble Sulfate (%)	Sulfide Content
B-2	7	Fat CLAY with sand	0.0162	7.3	351.6	655	0.003	Trace

4.5.1 Metal Corrosion

Laboratory testing was completed to provide data regarding corrosivity of onsite soils. Our scope of services does not include corrosion engineering and, therefore, a detailed analysis of the corrosion test results is not included. A qualified corrosion engineer should be retained to review the test results and design protective systems that may be required.

Metal and concrete elements in contact with soil, whether part of a foundation system or part of a supported structure, are subject to degradation due to corrosion or chemical attack. Therefore, buried metal and concrete elements should be designed to resist corrosion and degradation based on accepted practices.

Based on the "10-point" method developed by the American Water Works Association (AWWA) in standard AWWA C105/A21.5, the corrosivity test results indicate that the onsite soils have high corrosive potential. We recommend that a corrosion engineer be consulted to recommend appropriate protective measures, if required.

4.5.2 Chemical Sulfate Susceptibility and Concrete Type

The degradation of concrete or cement grout can be caused by chemical agents in the soil or groundwater that react with concrete to either dissolve the cement paste or precipitate larger compounds within the concrete, causing cracking and flaking. The concentration of water-soluble sulfates in the soils is a good indicator of the potential for chemical attack of concrete or cement grout. The American Concrete Institute (ACI) in their publication Guide to Durable Concrete (ACI 201.2R-08) provides guidelines for this assessment.

The concentration of water-soluble sulfates measured on subsurface clay materials submitted for testing represents a Class 0 exposure of sulfate attack on concrete exposed to the soils per CDOT Standard Specifications for Road and Bridge Construction, 2019, Section 601.04.

4.6 PAVEMENT RECOMMENDATIONS

4.6.1 General

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils and traffic loadings. Soils are represented for pavement design purposes by means of a soil support value.

Pavement design procedures are based on strength properties of the subgrade and pavement materials, along with the design traffic conditions.

We understand that new pavement areas on this site may include bridge approach drive lanes on either side of the bridge replacement on Wooten Road, and new pavement may potentially extend on the order of 300 feet north of the bridge to accommodate potential grade changes and drainage improvements. Our borings indicate the pavement subgrade soils will generally consist of sandy clay and clayey sand. These types of soils are generally considered to provide poor to fair support for pavements. Laboratory testing from samples obtained from the upper 4 feet of borings B-1 and B-2 resulted in a subgrade support value (R-value) of 24. Therefore, a resilient modulus (M_R) value of 5,593 psi was calculated and used in our pavement thickness calculations.

Our pavement investigation and thickness calculations were performed in general accordance with the City of Colorado Springs Pavement Design Criteria Manual, which is based on the 1993 American Association of State and Highway Transportation Officials (AASHTO) Guide for Design of Pavement Structures. Included herein are options for pavement section thickness design that meet the City of Colorado Springs Pavement Design Criteria Manual requirements, including the minimum required pavement section thickness for design based on the provided roadway classification/traffic loading (ESAL) and subgrade soil modulus.

The following sections describe in more detail the pavement section thickness design recommendations for areas requiring new pavement section construction.

4.6.2 Traffic Values

Based upon information provided by AECOM, the above-referenced pavement design manual, and the composite R-value sample of the pavement subgrade from the borings, the following table presents the pavement design parameters that were utilized in our design. These parameters were utilized to calculate required thickness of new Hot Mix Asphalt (HMA) and Aggregate Base Course (ABC) layers. The roadway classification of Minor Arterial was provided by AECOM.

Table 7
Summary of Pavement Design Parameters - New Flexible/HMA Pavement Section Construction

Pavement Design Parameters	
Roadway Classification	Minor Arterial
20 year, 18-kip ESAL*	2,500,000
Design Serviceability Loss (ΔPSI)*	2.0
Overall Standard Deviation*	0.44
Reliability [%]*	95
R-Value	24
Resilient Modulus (M_R) [psi]	5,593
Strength Coefficients	
New Hot Mix Asphalt*	0.44
New Aggregate Base Course*	0.12

*Indicates classification and pavement design parameter(s) obtained from the City of Colorado Springs Pavement Design Criteria Manual

If traffic estimates vary significantly from those assumed, we should be contacted to re-evaluate our recommendations. The following pavement sections were designed using the AASHTO design methods for flexible pavements and City of Colorado Springs Pavement Design Criteria. All pavement thickness recommendations based on ESAL values for mainlines only. Specific adjustments for turn-lanes, acceleration/deceleration lanes, shoulders, etc. are not included.

4.6.3 Design Section

Our recommended pavement section below is for the new pavement proposed for the roadway areas on Wooten Road. Material requirements and compaction specifications for HMA, ABC, and subgrade materials are presented in Sections 4.7.5 and 4.2.5, respectively. The following describes our recommended design section that includes the required thickness of HMA and ABC layers.

Table 8
Pavement Section Thickness Recommendations

Flexible Composite Section (HMA / ABC)
7” HMA / 12” ABC *over* properly prepared subgrade

4.6.4 Pavement Construction Considerations

All site preparation, earthwork operations and construction materials should be performed in accordance with applicable codes, safety regulations and other local, State or Federal guidelines as applicable including, but not limited to:

- City of Colorado Springs City Engineering Standard Specifications;
- City of Colorado Springs Pavement Design Criteria Manual;
- Pikes Peak Region Asphalt Paving Specifications Manual, and;
- Colorado Department of Transportation (CDOT), as applicable, and included by reference.

Of particular importance are those specifications directed towards embankment construction, subgrade compaction, base course compaction, and utility trench compaction. Prior to pavement construction, the prepared subgrade should be proof-rolled with heavy construction equipment. A fully loaded water truck would be acceptable for this purpose. During proof-rolling, particular attention should be directed to the area immediately adjacent to manholes, valves, catch basins, and other similar surface features. Areas which exhibit excessive deflection during proof-rolling should be over-excavated and stabilized as required. If soil is imported to the subject site for final grading, the soil materials must be of a character similar to those described in this report.

Proper drainage is of paramount importance in enhancing pavement performance. To avoid distress to pavement from wet subgrade soils, we recommend the maintenance of good drainage away from all pavements. Possible water sources include storm runoff, irrigation of landscaping adjacent the pavement and localized groundwater seepage, among others. Landscaping adjacent to the pavements should be avoided. Joints in the pavement or at asphalt/concrete interfaces should be sealed. Any cracks or openings in the finished pavement surface should be sealed and/or repaired as quickly as possible

4.6.5 Pavement Materials

The asphalt pavement should consist of a bituminous plant mix composed of a mixture of aggregate and bituminous material that meets the requirements of a job-mix formula established by a qualified engineer. We recommend Grading SX with PG 64-28 mix be utilized for the upper 2 inches (at a minimum), and Grading S with PG 64-22 mix be used for lower asphalt lifts. Hot Mix Asphalt (HMA) design and construction shall conform to the requirements of the current Pikes Peak Region Asphalt Paving Specifications Manual. The HMA pavement should be placed in lifts not to exceed 3 inches in thickness, unless otherwise accepted by the project engineer, and be compacted to between 92 percent and 96 percent of its maximum theoretical (Rice) density.

Aggregate Base Course (ABC) materials should conform to Section 300 of the City of Colorado Springs Standard Specifications. The ABC material should be placed in a uniform layer without segregation of size to a compacted maximum lift thickness of 6-inches. ABC should be moisture conditioned and compacted as described in Section 4.2.5 of this report.

Use of blankets, soil cover, or heating, may be required to help prevent the subgrade from freezing if construction occurs during cold weather.

4.6.6 Pavement Subgrade Preparation

Any obviously unsuitable materials present (e.g. debris, organic materials, waste) should be completely removed. Remove the stripped materials for offsite disposal in accordance with local laws and regulations.

Where embankment fill is required, the subgrade is to be scarified, moisture treated, and recompacted per Section 4.2.5 of this report to a depth of at least 8 inches. Regardless of the planned cut or fill depth, the zone of material below the bottom of the aggregate base course must include 8 inches of properly prepared subgrade.

Prior to placing the pavement section, the prepared subgrade should be proof-rolled with a heavily loaded pneumatic-tired vehicle (such as a fully-loaded water truck) after preparation. Areas that pump or deform significantly under heavy wheel loads are not stable and should be stabilized prior to paving. The method and extent of stabilization should conform to the City of Colorado Springs Pavement Design Criteria Manual and City of Colorado Springs Standard Specifications. The final stabilization approach/method and depth shall be approved by the Engineer.

5.0 ADDITIONAL SERVICES & LIMITATIONS

5.1 ADDITIONAL SERVICES

Attached to this report is a document by the Geoprofessional Business Association (GBA) that summarizes limitations of geotechnical reports as well as additional services that are required to further confirm subgrade materials are consistent with that encountered at the specific boring locations presented in this report. This document should be read in its entirety before implementing design or construction activities. Examples of other services beyond completion of a geotechnical report are necessary or desirable to complete a project satisfactorily include:

- Review of design plans and specifications to verity that our recommendations were properly interpreted and implemented.
- Attendance at pre-bid and pre-construction meetings to highlight important items and clear up misunderstandings, ambiguities, or conflicts with design plans and specifications.
- Performance of construction observation and testing which allows verification that existing materials at locations beyond our borings are consistent with that presented in our report, construction is compliant with the requirements/recommendations, evaluation of changed conditions.

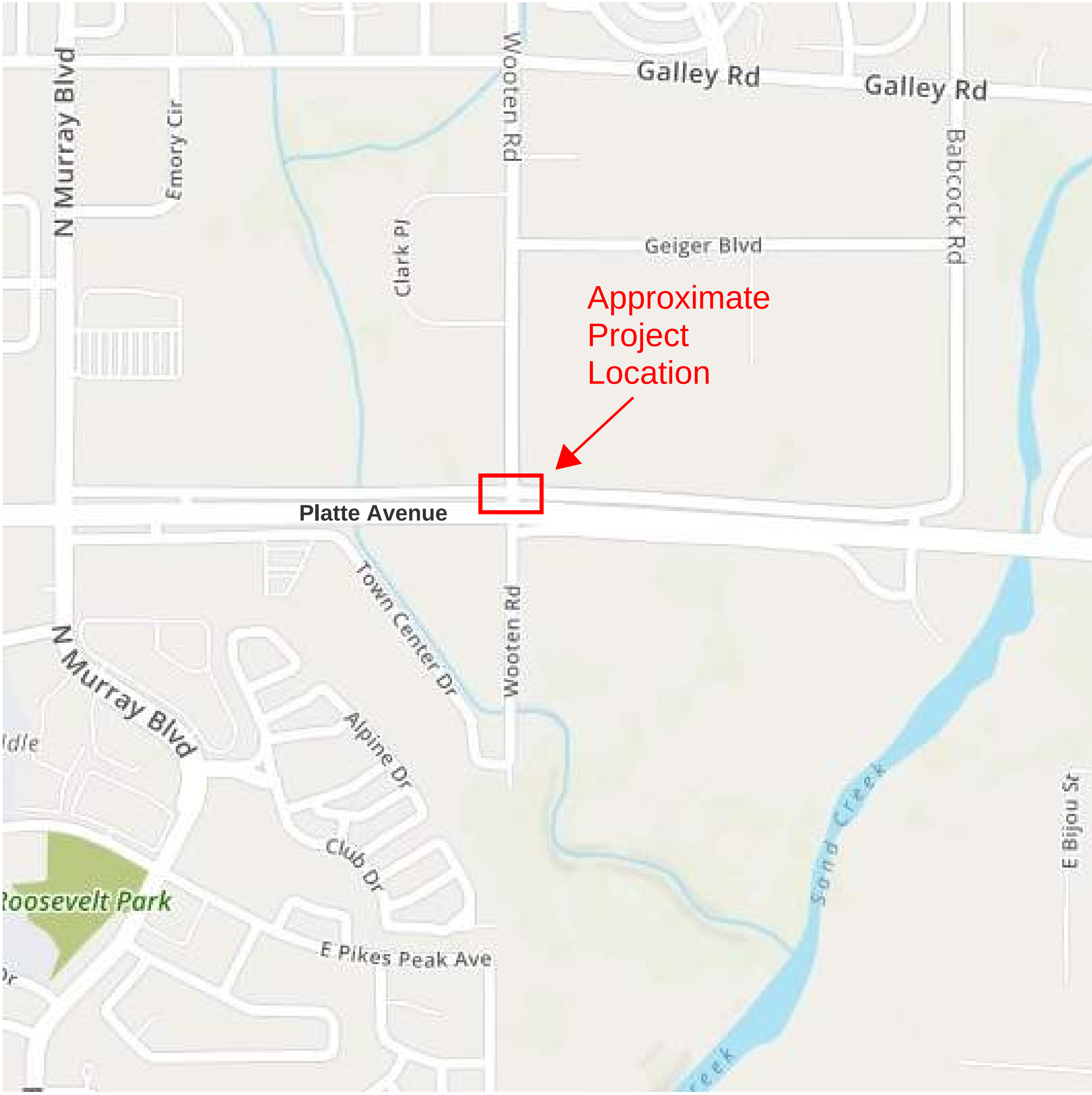
5.2 LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of VIVID's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. VIVID makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report.

The work performed was based on project information provided by Client. If Client does not retain VIVID to review any plans and specifications, including any revisions or modifications to the plans and specifications, VIVID assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, Client must obtain written approval from VIVID's engineer that such changes do not affect our recommendations. Failure to do so will vitiate VIVID's recommendations.

Figures



Not to Scale. Base image obtained from www.mapquest.com, 2019

VIVID Engineering Group	Project No: D19-2-268	**VICINITY MAP**	Figure
	Date: December 19, 2019		1
	Drawn by: MBR	Wooten Road at Platte Avenue Bridge Replacement Colorado Springs, Colorado	
	Reviewed by: WJB		

LEGEND

= APPROXIMATE LOCATION OF EXPLORATORY BORING

Base image dated 2018 and obtained from Google Earth, 2019.

VIVID Engineering Group	Project No: D19-2-268	**BORING LOCATION PLAN**	Figure
	Date: December 19, 2019		**2**
	Drawn by: MBR	Wooten Road at Platte Avenue Bridge Replacement Colorado Springs, Colorado	
	Reviewed by: WJB		

Appendix A

Logs of Exploratory Borings

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

BORING NUMBER B-1

CLIENT AECOM
PROJECT NAME Platte and Wooten Bridge Replacement
PROJECT NUMBER D19-2-268
PROJECT LOCATION Platte Avenue and Wooten Road
DATE STARTED 12/5/19 **COMPLETED** 12/5/19
GROUND ELEVATION **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 3" Solid Stem Auger
▽ **AT TIME OF DRILLING** 22.00 ft
LOGGED BY M.Ray **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB			0.5	Asphalt - 6 inches
	MC	15-15		2.0	Base Course - 18 inches Silty SAND with gravel, reddish brown, moist, medium dense
	GB				Fat CLAY with Sand, light brown, dark brown, olive, rust, moist to wet, soft to stiff
5	SPT	2-2-2 (4)	MC = 21.7% DD = 94.3 pcf		
	MC	3-5	Swell = 0.1% when wetted under 1000 psf load		
10	SPT	4-6-7 (13)	MC = 32.3% LL = 76 PL = 27 Fines = 91.0%		
15	MC	7-8	MC = 20.5% DD = 101.9 pcf		
20	SPT	3-2-2 (4)			
22					▽
25	MC	3-4		25.0	

Bottom of borehole at 25.0 feet.

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

BORING NUMBER B-2

CLIENT AECOM
PROJECT NAME Platte and Wooten Bridge Replacement
PROJECT NUMBER D19-2-268
PROJECT LOCATION Platte Avenue and Wooten Road
DATE STARTED 12/5/19 **COMPLETED** 12/5/19
GROUND ELEVATION **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 3" Solid Stem Auger
AT TIME OF DRILLING 22.00 ft
LOGGED BY M.Ray **CHECKED BY** B. Mustain
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB			0.5	Asphalt - 5 inches
				0.9	Base Course - 6 inches
	MC	10-12	MC = 7.9% LL = 18 PL = 16 Fines = 19.0%		Silty SAND with gravel, reddish brown, moist, medium dense Silty SAND, light brown to dark brown, moist, medium dense
	GB			3.0	Fat CLAY with sand, dark brown, moist, stiff
5	MC	6-6	UCS = 2981 psf Shear Strength = 1490 psf		
	SPT	5-5-8 (13)	MC = 30.9% LL = 63 PL = 25 Fines = 84.0%		
10	MC	6-9	MC = 34.4%		
				14.0	Clayey to Very Clayey SAND, light brown, moist to very moist, loose to medium dense
15	SPT	5-6-5 (11)			
20	MC	4-3	MC = 23.8% DD = 96.2 pcf		
25	SPT	3-2-3 (5)		25.5	

Bottom of borehole at 25.5 feet.

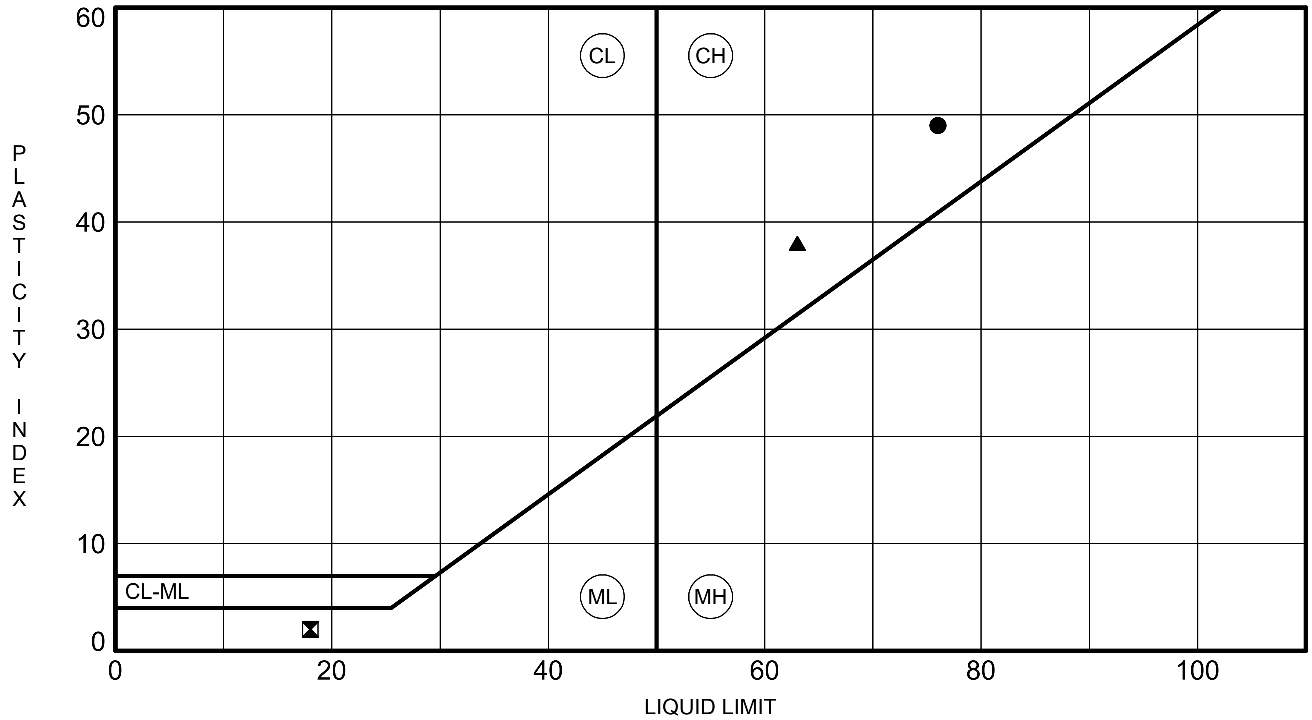
Appendix B

Geotechnical Laboratory Test Results

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

ATTERBERG LIMITS' RESULTS

CLIENT AECOM
PROJECT NAME Platte and Wooten Bridge Replacement
PROJECT NUMBER D19-2-268
PROJECT LOCATION Platte Avenue and Wooten Road

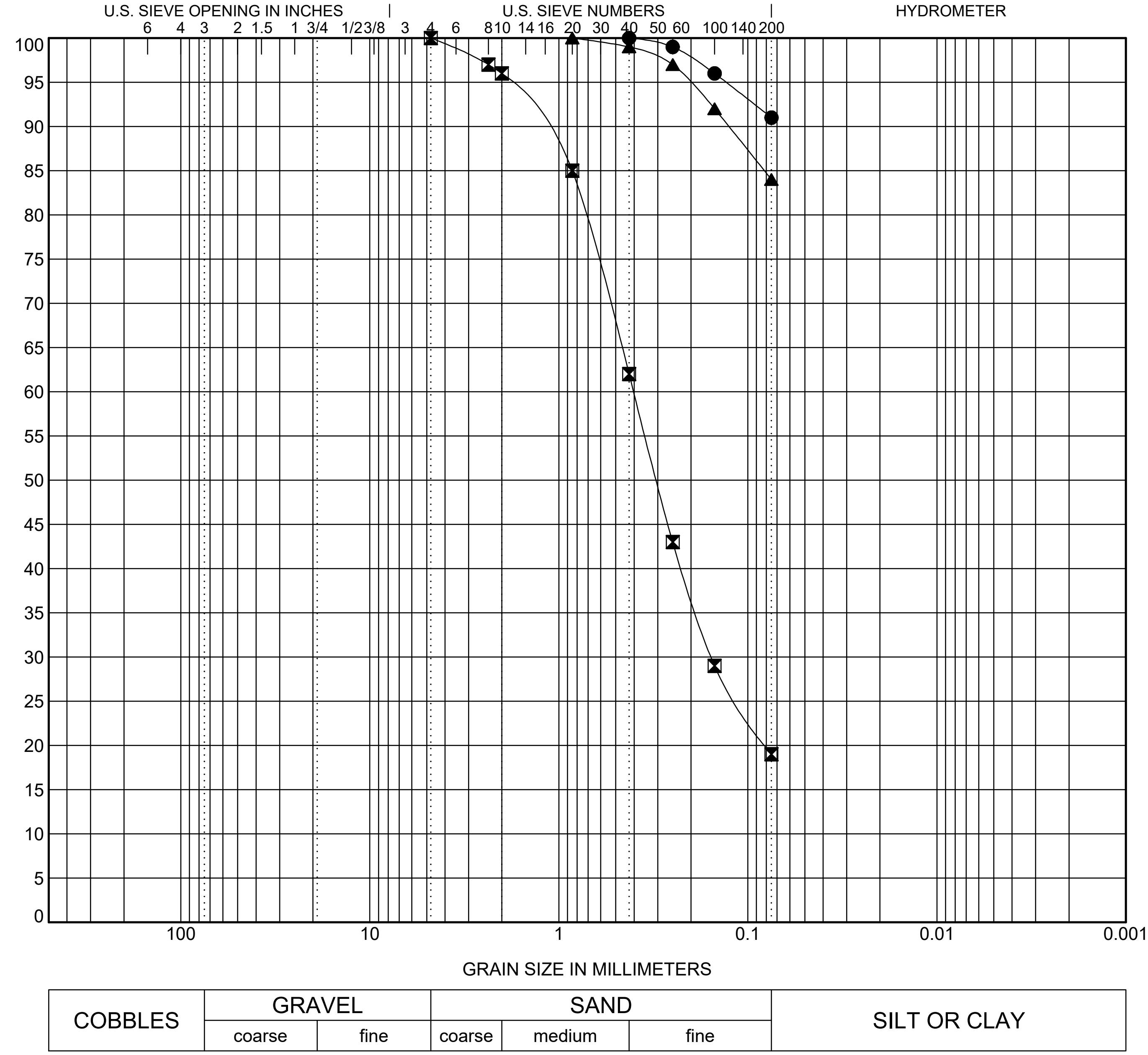


	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-1**	**9.0**	**76**	**27**	**49**	**91**	**FAT CLAY(CH)**
⊠	**B-2**	**1.0**	**18**	**16**	**2**	**19**	**SILTY SAND(SM)**
▲	**B-2**	**7.0**	**63**	**25**	**38**	**84**	**FAT CLAY with SAND(CH)**

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

GRAIN SIZE DISTRIBUTION

CLIENT AECOM
PROJECT NAME Platte and Wooten Bridge Replacement
PROJECT NUMBER D19-2-268
PROJECT LOCATION Platte Avenue and Wooten Road



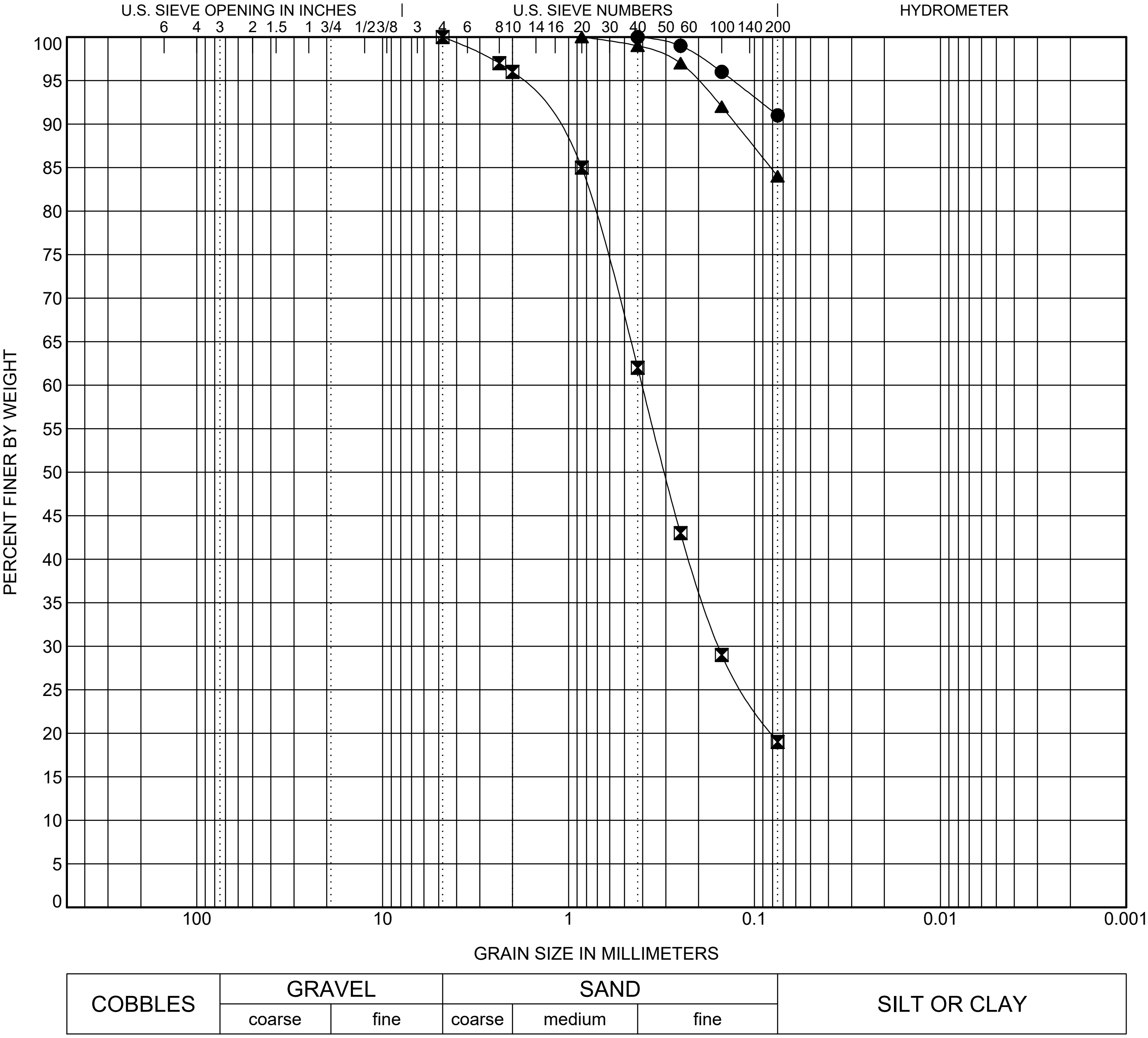
BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
● **B-1**	**9.0**	**FAT CLAY(CH)**	**76**	**27**	**49**		
⊠ **B-2**	**1.0**	**SILTY SAND(SM)**	**18**	**16**	**2**		
▲ **B-2**	**7.0**	**FAT CLAY with SAND(CH)**	**63**	**25**	**38**		

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-1**	**9.0**	**0.425**				**0.0**	**9.0**	**91.0**	
⊠ **B-2**	**1.0**	**4.75**	**0.402**	**0.156**		**0.0**	**81.0**	**19.0**	
▲ **B-2**	**7.0**	**0.85**				**0.0**	**16.0**	**84.0**	

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

GRAIN SIZE DISTRIBUTION

CLIENT AECOM
PROJECT NAME Platte and Wooten Bridge Replacement
PROJECT NUMBER D19-2-268
PROJECT LOCATION Platte Avenue and Wooten Road



	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**B-1**	**9.0**	**(A-7-6)**	**76**	**27**	**49**		
⊠	**B-2**	**1.0**	**(A-2-4)**	**18**	**16**	**2**		
▲	**B-2**	**7.0**	**(A-7-6)**	**63**	**25**	**38**		

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-1**	**9.0**	**0.425**				**0.0**	**9.0**	**91.0**	
⊠	**B-2**	**1.0**	**4.75**	**0.402**	**0.156**		**0.0**	**81.0**	**19.0**	
▲	**B-2**	**7.0**	**0.85**				**0.0**	**16.0**	**84.0**	

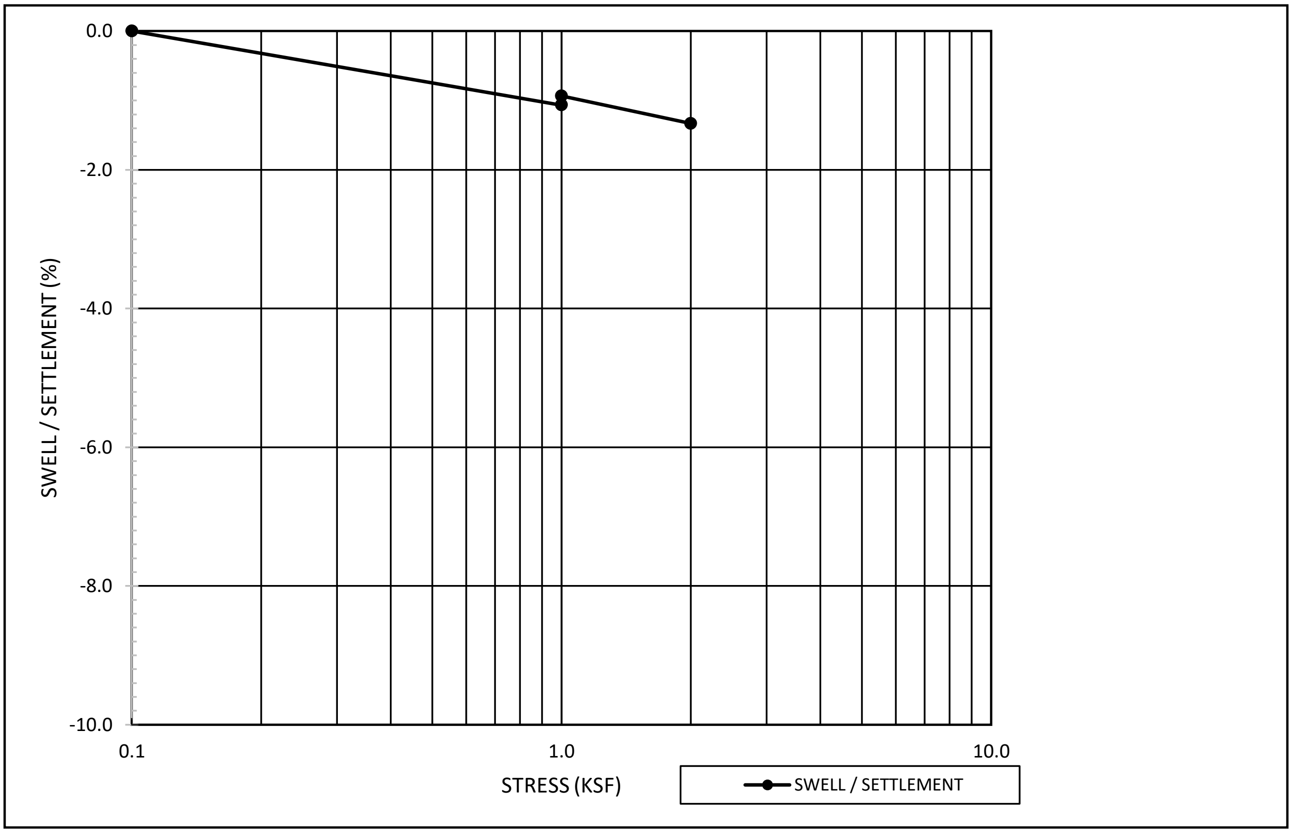
GRAIN SIZE AASHTO - GINT STD US LAB.GDT - 12/17/19 13:10 - S:\VIVID PROJECTS\D19-2-268_AECOM - PLATTE & WOOTEN BRIDGE_GEO\6 - DRAFTING\D19-2-268_PLATTE AND WOOTEN BRIDGE REPLACEMENT.GPJ

VIVID Engineering Group, Inc.

Project Name:	Platte & Wooten Bridge Replacement	**Date**	12/6/2019
Project No.:	D19-2-268		
Boring ID.:	B-1	**Sample Depth (ft)**	7
Sample Description:	Clay, sandy, dark gray-brown, very moist		

VIVID Engineering Group

	%
Swell @ Wetting Weight:	**0.1**



Initial Condition	
Moisture Content %	**31.3**
Dry Density (pcf)	**87.1**
Post-Swell Condition	
Moisture Content %	**32.7**

UNCONFINED COMPRESSION TEST
ASTM D 2166

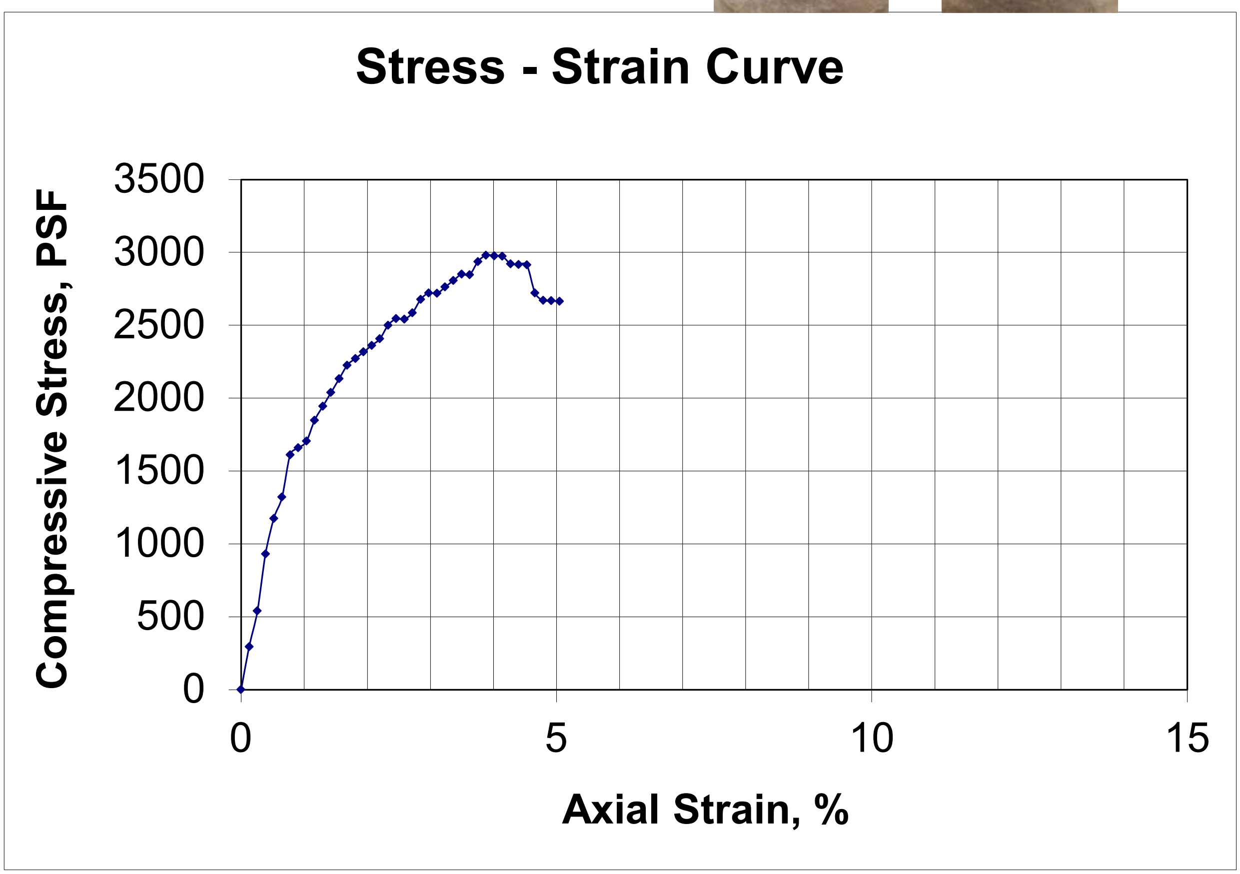
PROJECT NAME:	Platte & Wooten Bridge	PROJECT ENG.:	BTM
PROJECT NO. :	D19-2-268	DATE RECEIVED:	12/6/2019
CLIENT NAME:	AECOM	DATE TESTED:	12/6/2019
		TESTED BY:	TK
BORING NO. :	B-2	DATA ENTRY:	TK
SAMPLE NO.:	0		
DEPTH, FT. :	4.5ft	DESCRIPTION:	CLAY, sandy, dark brown
TEST SPECIMEN NO.:	0		

INITIAL DATA

Avg. Height, In.:	3.863
Avg. Diameter, In.:	1.930
L/D Ratio:	2.0
Moisture Content, %: (Sample, After test)	21.7
Dry Density, pcf:	94.3
Assumed Specific Gravity:	2.7
Saturation, %:	74.7
Void Ratio:	0.786
Rate of Strain, %/Minute:	1.0

Photo:

	PSF	PSI
Compressive Strength @ Failure:	2981	21
Shear Strength @ Failure:	1490	10
Axial Strain @ Failure,%:	5.2	5.2

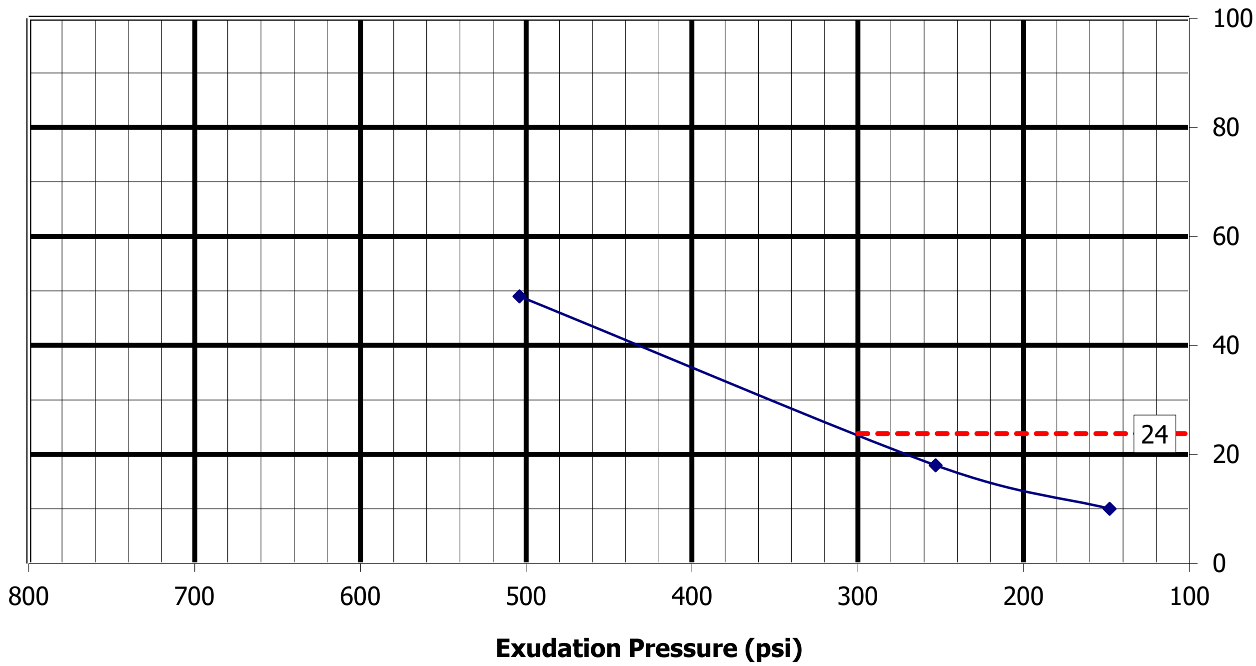


CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

AASHTO ACCREDITED

R-VALUE TEST GRAPH (ASTM D2844)

Project Number:	19.019, Vivid Engineering Group, Inc.	Date:	8-Dec-19
Project Name:	Platte & Wooten Bridge (Vivid Project No. D19-2-268)	Technician:	G. Hoyos
Lab ID Number:	1921902	Reviewer:	G. Hoyos
Sample Location:	Composite: B-1 and B-2 at 0' to 4'		
Visual Description:	SAND, clayey, with gravel, brown		



R-Value @ Exudation Pressure 300 psi:	**24**
Specification:	

CDOT Pavement Design Manual, 2011.
Eq. 2.1 & 2.2, page 2-3.

$S_1 = [(R-5)/11.29]+3$ **S_1= 4.67**

$M_R = 10^{[(S_1+18.72)/6.24]}$ **M_R= 5,593**

M_R = Resilient Modulus, psi

S_1 = the Soil Support Value

R = the R-Value obtained

Test Specimen:	1	2	3
Moisture Content, %:	9.7	11.2	12.4
Expansion Pressure, psi:	0.30	0.00	-0.27
Dry Density, pcf:	126.7	122.6	121.5
R-Value:	49	18	10
Exudation Pressure, psi:	504	253	148

Note: The R-Value is measured; the M_R is an approximation from correlation formulas.

Corporate: 7108 South Alton Way, Building B • Centennial, Colorado 80112
Phone 303-220-0300 • www.cesareinc.com

Appendix C

Analytical Laboratory Test Results

Colorado Analytical
LABORATORIES, INC.

Analytical Results

TASK NO: 191211002

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs CO 80907

Task No.: 191211002
Client PO:
Client Project: Wooten and Platte Bridge D19-2-268

Date Received: 12/11/19
Date Reported: 12/18/19
Matrix: Soil - Geotech

Customer Sample ID B-2 @ 7ft
Lab Number: 191211002-01

Test	Result	Method
Chloride - Water Soluble	**0.0162 %**	AASHTO T291-91/ ASTM D4327
pH	**7.3 units**	AASHTO T289-91
Redox Potential	**351.6 mv**	ASTM D1498
Resistivity	**655 ohm.cm**	AASHTO T288-91
Sulfate - Water Soluble	**0.003 %**	CDOT CP-L 2103 / ASTM D4327
Sulfide	**Trace**	AWWA C105

Abbreviations/ References:

AASHTO - American Association of State Highway and Transportation Officials.
ASTM - American Society for Testing and Materials.
ASA - American Society of Agronomy.
DIPRA - Ductile Iron Pipe Research Association Handbook of Ductile Iron Pipe.

Shane Nielson

DATA APPROVED FOR RELEASE BY

10411 Heinz Way / Commerce City, CO 80640 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507

Appendix D

Important Information About This Geotechnical Engineering Report

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

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